Phys 131
Fall 2016

Fundamental Mechanics: Class Exam 2

12 October 2016

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excellent

Instructions

- There are 7 questions on 5 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s^2}$

Question 1

A rope pulls horizontally on a 50 kg cart which moves along a rough horizontal surface. The air exerts a 200 N force opposite to the direction of motion. At one instant the cart moves right with velocity 10 m/s and has a rightward acceleration of $6.0\,\mathrm{m/s^2}$. Determine the tension in the rope at this instant.

m=50 kg
W= 200N

object is moving to the right a is positive

F	X	Y
T	T	0
W	-200N	0

$\sum F_x = ma_x$

$\sum_x T - 200N = ma_x$

$T = 200N + ma_x$

m= 50 kg
a= 6.0 m/s²

$T = 200N + 50kg(6.0\,m/s^2)$

$T = 200N + 300N$

$T = 500N$

$T = 500N$

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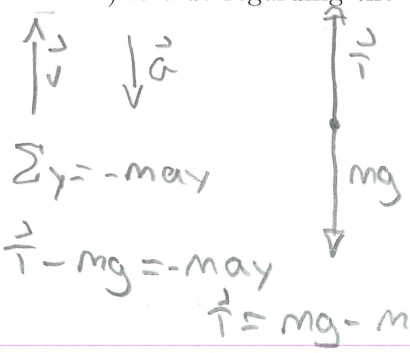
Question 2

A phone, with mass m, is suspended from a rope. The phone moves vertically up with a decreasing speed and while this happens there is no slack in the rope. Which of the following (choose one) is true regarding the tension in the rope?

i) $T = 0\,\text{N}$.
ii) $0 < T < mg$.
iii) $T = mg$.
iv) $T > mg$.



$\Sigma F_y = -ma_y$

$T - mg = -ma_y$

$T = mg - ma_y$

$T \neq 0$, rope would be slack

$\therefore 0 < T < mg$ 4/4

Question 3

A 0.040 kg ball is initially at rest at the bottom of a frictionless 1.2 m tall vertical tube. While the ball is in the tube, the ball is pushed by air which exerts a constant upward force of 1.5 N on the ball. Determine the velocity of the ball when it reaches the top of the tube.

$m = 0.040$ kg

upward force $= 1.5$ N

$\vec{F} = 1.5$ N

$F = ma$

Object is accelerating up

$\therefore \Sigma F_y = ma_y$

$\Sigma F_y = F - mg = ma_y$

Velocity at top is v_1

$t_0 = 0$ s

$y_0 = 0$ m

$v_{0y} = 0$ m/s

$a_y = 27.7\ \text{m/s}^2$

$t_1 =$

$y_1 = 1.2$ m

$v_{1y} = 8.15$ m/s

$\Delta y = 1.2$ m

$\vec{F} = 1.5$ N

$m = 0.04$ kg

$g = 9.8\ \text{m/s}^2$

$\frac{F - mg}{m} = a_y$

$\frac{1.5\text{N} - 0.04\text{kg}(9.8\text{m/s}^2)}{0.04\text{kg}} = a_y$

$a_y = 27.7\ \text{m/s}^2$

$v_{1y}^2 = v_{0y}^2 + 2a_y \Delta y$

$v_{1y}^2 = (0\text{m/s})^2 + 2(27.7\text{m/s}^2)(1.2\text{m})$

$v_{1y}^2 = 55.4\ \text{m/s}^2(1.2\text{m})$

$v_{1y}^2 = 66.48\ \text{m}^2/\text{s}^2$

$v_{1y} = 8.15$ m/s

velocity at top is 8.15 m/s

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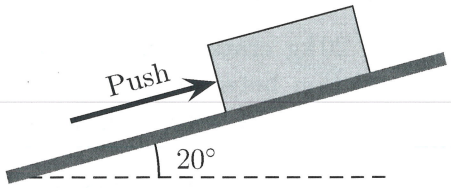
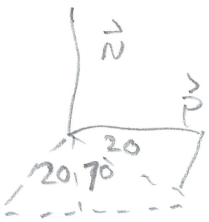
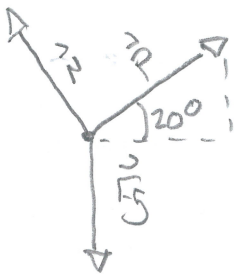
Question 4

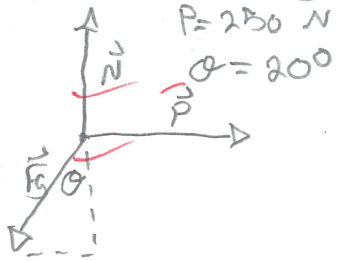
A 50 kg box lies on the illustrated frictionless inclined ramp. You push parallel to the ramp against the block with a force of 250 N. Determine the acceleration of the box while you push it.

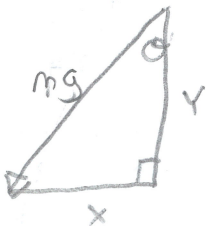






$\vec{P}$ = push m = 50 kg P = 250 N $\theta = 20^\circ$





Box moves right

$\vec{a} \rightarrow \quad \therefore \quad \Sigma F_{net} = ma$

X-component: $-mg\sin\theta$

Y-component: $-mg\cos\theta$

F	X	Y
$\vec{N}$	0	N
P	250N	0
$\vec{F}_g$	$-mg\sin\theta$	$-mg\cos\theta$

At rest vertically

$\Sigma_y = 0$

$\Sigma_y = \vec{N} - mg\cos\theta = 0$

$\vec{N} = mg\cos\theta$ ... $50\,kg(9.8\,m/s^2)\cos 20$

$\vec{N} \approx 460.449\,N$

$\Sigma_x = \vec{a} \rightarrow ma$ Object moves right

$\Sigma_x = 250N - mg\sin\theta = ma$

$250N - (50kg)(9.8m/s^2)\sin 20 = 50kg \cdot a$

$250N - 167.59N = 50kg\,a$

$82.4101\,N = 50\,kg\,a$

$a = 1.65\ m/s^2$

acceleration is $1.65\ m/s^2$

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$\Sigma_x = ma_x$

$200N - 0.50(196N) = 20kg\,a$ $\quad \Sigma_x = ma_x$ $\quad \Sigma_y = 0$ $\quad \vec{N} - mg = 0$

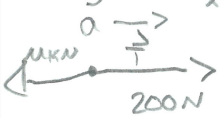
$200N - 98N = 20kg\,a$ $\quad \vec{T} - \mu_K N = ma_x$ $\quad \vec{N} = mg$

$102N = 20kg$ $\quad a = 5.1\,m/s^2$ $\quad \vec{N} = 20kg \cdot 9.8\,m/s^2 = 196N$

Question 5

A 20 kg crate is initially at rest on a rough horizontal surface. The coefficient of kinetic friction between the crate and surface is 0.50. During an initial 10 s period a rope pulls horizontally with a tension of 200 N. This is sufficient to exceed static friction.

Horizontally Pulled



a) Which of the following is true during this initial 10 s period?

$a = 5.1\,m/s^2$ $\quad \frac{\Delta v}{\Delta t} = a$

i) The crate moves with constant speed.

ii) The crate moves with a speed that constantly increases.

iii) The crate moves with a speed that briefly increases and then stays constant.

iv) The crate moves with a speed that briefly increases and then starts to drop.

b) After this initial period, the tension in the rope drops at a steady rate to 150 N and this takes another 5.0 s. Which of the following is true during this 5.0 s period?

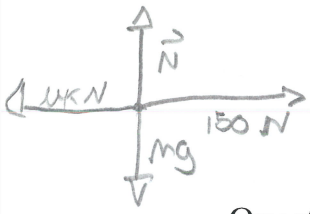
i) The crate moves with constant speed.

ii) The crate moves with a speed that constantly increases.

iii) The crate moves with a speed that constantly decreases.

iv) The crate moves with a speed that briefly decreases and then stops.

$a = 0.13\,m/s^2$



$N = 196N$ $\quad \mu_K = 0.50$

$\Sigma_x = ma_x$ $\quad 150N - 98N = 20kg\,a$ $\quad a = 0.13\,m/s^2$

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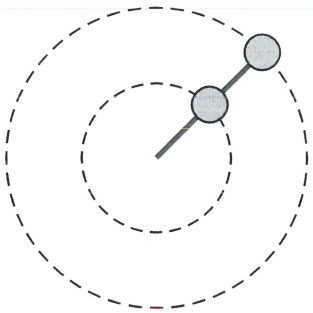
Question 6

Two 3.0 kg balls are attached by strings and each moves on a frictionless horizontal surface in a circle with the same angular velocity, 15 rad/s. The outer ball follows a path with radius 4.0 m and the inner ball one with radius 2.0 m. The diagram shows this viewed from above. Determine the tension in the outer string.



$\Sigma F = ma_c$

$v = 15\,rad/s$ $\quad r = 4.0m$

$v = \omega r$ $\quad$ v, w mixed up. -2

$15\,rad/s = \omega(4.0m)$ $\quad \omega = 3.75$

$\frac{15\,rad/s}{4.0m} = \omega$

$\Sigma F = ma_c$

$\vec{T} = m(\omega^2 r)$

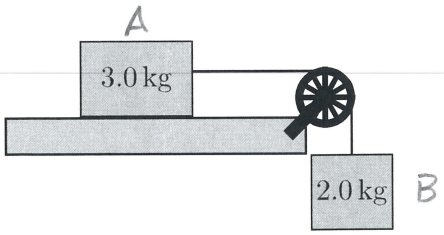
$\vec{T} = 3.0kg(3.75^2)(4.0m)$

$\vec{T} = 168.75\,N$ 6 /8

$\vec{T} = 168.75\,N$

Question 7

Two blocks are connected by a string, which runs over a massless pulley. One block is suspended and the other block can move along a frictionless horizontal surface. The string connected to the block on the surface runs horizontally.



a) Determine the acceleration of the blocks.

massless string $\vec{T}_1 = \vec{T}_2$

object isn't moving vertically

(A) $\sum F_y = 0$

$\vec{N} - mg = 0$

$\vec{N} = mg$

$\sum F_x = m_A a_x$

$T_1 = m_A a_x$

(B) $\sum F_y = T_2 - m_B g = -m_B a_y$

$T_2 = m_B g - m_B a_y$

$T_1 = T_2$

$a_x = a_y$

$\sum F_{net} = ma_y$

$m_B g - m_B a = m_A a$

$m_B g = m_B a + m_A a$

$m_B g = a(m_B + m_A)$

$a = \dfrac{m_B g}{m_B + m_A}$

$m_B = 2.0\,kg$

$m_A = 3.0\,kg$

$a = \dfrac{2.0kg(9.8\,m/s^2)}{2.0kg + 3.0kg} = \dfrac{19.6\,N}{5\,kg} = 3.92$

acceleration is

$a = 3.92\ m/s^2$

b) Determine the tension in the string.

$T_1 = m_A a$ $\quad T_2 = m_B g - m_B a$

$m_A = 3.0kg$

$m_B = 2.0kg$

$a = 3.92\ m/s^2$

$T_1 = 3.0kg(3.92\,m/s^2)$

$T_1 = 11.76\,N$

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